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EVALUATION OF MINE SAFETY APPLIANCE (MSA) PASSIVE FUEL VAPOR MONITOR, PROTOTYPES MSA 16-72, MSA 17-72, AND MSA 18-72.

HQ AFLC/LGTPM
AIR FORCE PACKAGING EVALUATION AGENCY
WRIGHT-PATTERSON AFB, OH 45433-5999

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NOTICE

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TITLE: Evaluation of Mine Safety Appliances (MSA) Passive JP-10 Fuel Vapor Monitor, Prototypes MSA 16-72, MSA 17-72, and MSA 18-72

ABSTRACT

At the request of ASD/VBL, Mine Safety Appliances Company developed a passive change of color JP-10 fuel vapor monitor for the Tacit Rainbow missile container. The Tacit Rainbow missile is shipped and stored as a fueled all up round. In the event of a fuel leak, it is desirable to be able to detect JP-10 vapor at 20 to 30 percent of the lower explosive limit (LEL) in order to avoid an ordanance safety hazard condition. The indicator must also perform reliably in the missile shipping and storage environment of -40 C to +60 C and 0 to 30 percent relative humidity. The MSA passive JP-10 fuel vapor monitor is a change of color device with indication from chromate yellow unexposed to turquoise green upon exposure to JP-10 vapor in concentrations above 1000 parts per million and progressing to dark brown with increasing time and concentration. The indicator media is chromate base absorbed on silica-gell located in one end of a flat face sealed 9 mm glass tube. The tube is mounted in a standard 1 inch relative humidity indicator housing with a glass viewing window by means of a teflon insert holder.

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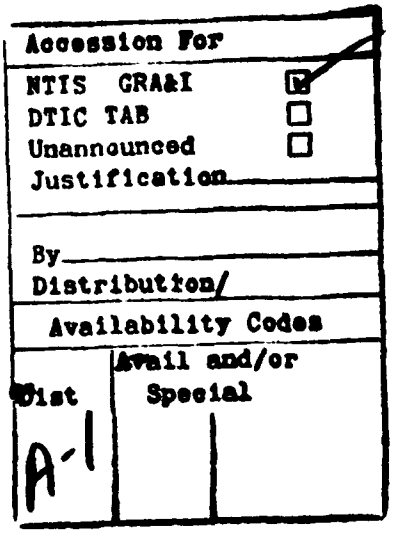

INTRODUCTION

At the request of ASD/VBL, Mine Safety Appliances Company (MSA) developed a passive change of color JP-10 fuel vapor monitor for the Tacit Rainbow missile container. The Tacit Rainbow missile is shipped and stored as a fueled all up round. In the event of a fuel leak, it is desirable to be able to detect JP-10 vapor at 20 to 30 percent of the lower explosive limit (LEL) in order to avoid an ordnance safety hazard condition. The indicator must also perform reliably in the missile shipping and storage environment of -40 C to +60 C and 0 to 30 percent relative humidity. HQ AFLC/ LGTPM was assigned the responsibility of evaluating the JP-10 fuel monitor performance. Passive JP-10 fuel vapor monitors, prototypes MSA 16-72, MSA 17-72, and MSA 18-72, 12 Oct 90, are the third submission for evaluation by MSA.

ITEM DESCRIPTION

The MSA passive JP-10 fuel vapor indicator is a change of color device indicating from chromate yellow unexposed to turquoise green upon exposure to JP-10 vapor in concentrations above 1000 Parts Per Million (PPM) and progressing to dark brown with increasing time and concentration. The indicator media is chromate base absorbed on silica-gell located in one end of a flat face sealed 9 mm glass tube. A water vapor barrier layer of silica-gell located between the indicator media and the open tube end protects against the desensitizing effect of excessive water vapor. The indicator tube is supplied sealed and is opened for use. The tube is mounted in a standard 1 inch relative humidity indicator housing with a glass viewing window by means of a teflon insert holder. Two styles of teflon holders are available. The original holder with a cylindrically drilled hole was satisfactorily evaluated regarding mechanical testing properties on 30 Oct 89. The new holder currently being evaluated has a star pattern punched or extruded hole.

TEST PROCEDURE

Environmental Aging.

Prior to JP-10 exposure, the indicator tubes were opened and subjected to an environmental aging period of 24 hours at -40 C (-40 F) and 168 hours at +60 C (+140 F) and 26-28 percent relative humidity.

JP-10 Indication.

The indicator tubes were then mounted in the housings which were mounted in vented 3.5 inch I.D. x 2.14 inch depth aluminum cups with an aluminum adaptor plate. The cups were placed in a controlled temperature environmental chamber and allowed to come into thermal equilibrium at -17.7 C (0 F). At -17.7 C, 2.0 cc of JP-10 were injected into each cup. At -17.7 C, JP-10 vapor in equilibrium with liquid is estimated to have a vapor concentration

of 1750 PPM by weight by extrapolating JP-10 vapor pressure data extending to 5 C. As a minimum, observation for color changes were made in the mornings and evenings of workdays and hourly several times when temperature was changed. After a minimum exposure period of at least 48 hours, temperature was incremented sequentially through the temperatures 0 C (5 percent (LEL), 20 C (20 percent LEL), 30 C (33 percent LEL), and 60 C to establish test JP-10 vapor concentrations and respective indicator response. At the end of test, excess JP-10 liquid was measured to determine that liquid JP-10 was present during the test period.

Mechanical Testing.

After evaluation of JP-10 indication performance, MSA 18-72 (#7, 8, and 9) indicators were placed in holders with star pattern teflon inserts, and subjected to MIL-STD-810D, Method 516.3, Shock, Procedure V, Crash Hazard and FED-STD-101C, Method 5019.1, Vibration (Repetitive Shock) Tests. Indicators #7, 8, and 9 were subjected to three 75 Gp acceleration, 5 msec duration terminal peak triangular shock pulses in each direction of their of their principal axes for a total of 18 shocks. A Monterey Research Laboratory programmable shock test machine was used to generate the terminal peak triangular shock pulses. Indicators #7, 8, and 9 were then subjected to unsecured vibration of 4.5-4.6 Hz frequency and 1.1 Gp acceleration for 30 minutes on each principal axis direction. The vibration test was performed on a L.A.B. Division electrohydraulic vibration test machine. Test frequency was monitored by a Hewlett-Packard timer/counter. Both shock and vibration test acceleration amplitudes were monitored by a piezo-electric accelerometer, charge amplifier, and storage oscilloscope instrumentation system.

TEST EQUIPMENT

The following test equipment was used in the performance of the above testing:

ITEM	MANUFACTURER	MODEL	SERIAL	CAL EXP
Shock test mach.	Monterey Research	IMPAC 2424	6	N/A
Sawtooth accel. programmer	Monterey Research	MRL 6080	2	N/A
Hydraulic vibration system	L.A.B. Division	8900	89003	N/A
Chamber envir.	Tenney Engineering		A088891	3 Jun 91
Oven drying	A-C LAB			N/A
Thermometer merc.	Fisher Scientific	Laboratory		
Oscilloscope	Tektronix	564B	B112535	8 Jul 91
Timer/counter	Hewlett-Packard	5304A	A087684	7 Apr 91
Charge amplifier	ENDEVCO	2740B	FW10	18 Jun 91
Accelerometer	ENDEVCO	2233E	CC98	16 Sep 91
Indicator relative humidity				

TEST RESULTS

Environmental Aging.

Three specimens of each indicator type, MSA 16-72 (#1, 2, and 3), MSA 17-72 (#4, 5, and 6), and MSA 18-72 (#7, 8, and 9), were evaluated. Initially, all indicator colors were chromate yellow of equal intensity. After 24 hours exposure at -40 C, all indicator colors remained chromate yellow of equal intensity. After 168 hours exposure at +60 C and 26-28 % relative humidity, indicators #7,8, and 9 were slightly lighter in color than an unopened tube, but darker than indicators #1, 2, 3, 4, 5, and 6. Within the groups, color intensities are approximately equal at +60 C. On cooling to room temperature, indicators #1, 2, 3, 4, 5, and 6 remained yellow, but developed a very light green tint which while too light to be considered a false indication, may cause questions of interpretation. Great care was exercised to avoid JP-10 contamination of the test area or inadvertent JP-10 exposure. At this point, the opened indicator tubes were placed in housings for the JP-10 exposure tests.

JP-10 Indication.

After 5.3 hours exposure to JP-10 vapor at -17.7 C in equilibrium with liquid, indicators #5 and 6 developed a distinctive green tint on predominantly yellow and may have indicated. After 29 hours at -17.7 C, indicators #5 and 6 are predominantly turquoise green and have indicated JP-10 vapor. After 29 hours at -17.7 C, indicators #1, 2, 3, 4, 7, 8, and 9 have developed a distinctive green tint on predominantly yellow and may have indicated. After 93 hours at - 17.7 C, indicators #1, 2, 3, 4, 7, 8, and 9 have continued to develop a darker green tint on predominantly yellow, but may not have reliably indicated due to slightness of the green tint. After 93 hours, test temperature was increased to 0 C.

After 2 hours exposure to JP-10 vapor at 0 C in equilibrium with liquid, indicators #1, 2, 3, 4, 5, 6, 7, 8, and 9 are predominantly turquoise green of equal intensity and have indicated JP-10 vapor. After 48 hours at 0 C, the color and intensity of the predominantly turquoise green of the test indicators match or are darker than the indicator tube exposed by MSA at our December, 1990 meeting. At 48 hours, no indication of the green to brown transition is present. After 48 hours, test temperature was increased to 20 C.

After 2 hours exposure to JP-10 vapor at 20 C in equilibrium with liquid, indicators #1, 2, 3, 4, 5, 6, 7, 8, and 9 exhibit a positive green indication with a brown tint developing. After 51 hours at 20 C, all indicators exhibit a positive green indication with a brown tint. At 51 hours, test temperature was increased to 30 C.

After 3 hours exposure to JP-10 vapor at 30 C in equilibrium with liquid, indicators #1, 2, 3, 4, 5, 6, 7, 8, and 9 are predominantly yellow with a faded green tint. After 66.5 hours at 30 C, indicators #1, 2, 3, 4, 5, 6, 7, 8, and 9 are light yellow with a very slight green tint and #6 exhibits brown speckles. After 99 hours at 30 C, indicators #1, 2, 3, 4, 5, and 6 are light yellow with a very slight green tint, #6 exhibits brown speckles, and #7, 8, and 9 have a distinct brown tint. After 146 hours at 30 C, indicators #1, 2, 3, 4, and 5 are light yellow with a slight brown tint, #6 exhibits more brown speckles, and #7, 8 , and 9 have a darker distinct brown tint. After 218 hours at 30 C, indicators #1, 2, 3, 4, 5, and 6 are light yellow with a slight brown tint, #6 and 9 exhibit brown speckles, and #7, 8, and 9 have a darker brown tint. At 218 hours, test temperature was increased to 60 C.

After 6.7 hours exposure to JP-10 vapor at 60 C in equilibrium with liquid, indicators #1, 2, 3, 4, and 5 are light yellow with a light brown tint and #6, 7, 8, and 9 are light brown. After 22.4 hours at 60 C, indicators #1, 2, 3, and 4 are light yellow-brown, #5 is light brown, and #6, 7, 8, and 9 are medium brown. After 48 hours at 60 C, indicators #1, 2, and 3 are light brown, #4, 5, and 6 are medium brown, and #7, 8, and 9 are brown to dark brown. At 48 hours, the indication test was discontinued.

Mechanical Testing.

Indicators #7, 8, and 9 (MSA 18-72) mounted in the star pattern teflon insert satisfactorily sustained mechanical testing without damage or malfunction of the holding ability of the teflon insert or housing.

CONCLUSIONS AND RECOMMENDATIONS

After environmental aging at -40 C and +60 C, all indicators have reliably indicated JP-10 vapor at 0 C by green color, may have indicated at -17.7 C, and have progressed through an indication color sequence of yellow to green to brown as the stable terminal color. #7, 8, and 9 appear to provide somewhat better results; therefore, the MSA 18-72 indicator is recommended as the first choice for use. Both the cylindrical drilled hole and the star pattern hole teflon inserts provide satisfactory mechanical performance.

Due to the difficulty of color interpretation, it is recommended that a reference color chart of both indicated and non-indicated states colors be placed on the indicator front face. The reference color chart is essential because many of the indicted state colors are light tints of green or brown on predominant yellow base color or light tints of green or yellow on predominant brown base color in a state of continuous transition. Discrimination between lighter hues of brown and yellow is

particularly difficult and would be almost impossible without a color reference chart.

It is also recommended that the JP-10 indicator be read in field use only under well illuminated conditions. Instructions should accompany the indictor stating that reading illumination should be natural sun light, or light from an incandescent source or fluorescent lamp which closely approximates natural sun light. Otherwise, the subjunctive aspects of color interpretation will be severely aggravated and reading error will result.

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APPENDIX 1

FIGURES

Figure 1. Open Indicator Tube in Housing, Side View

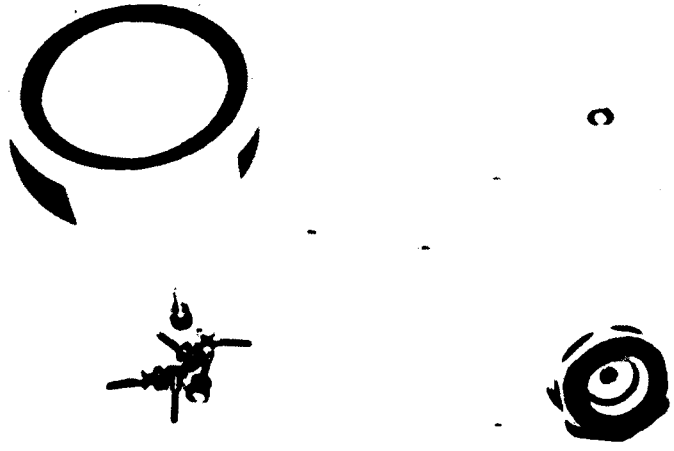

Figure 2. Test Cup, Sealed Indicator Tube, and Housing, Front View.

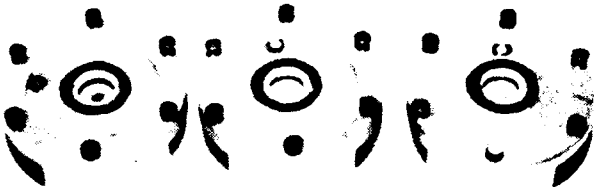

Figure 3. Test Cups with JP-10 Monitors, Assembled.

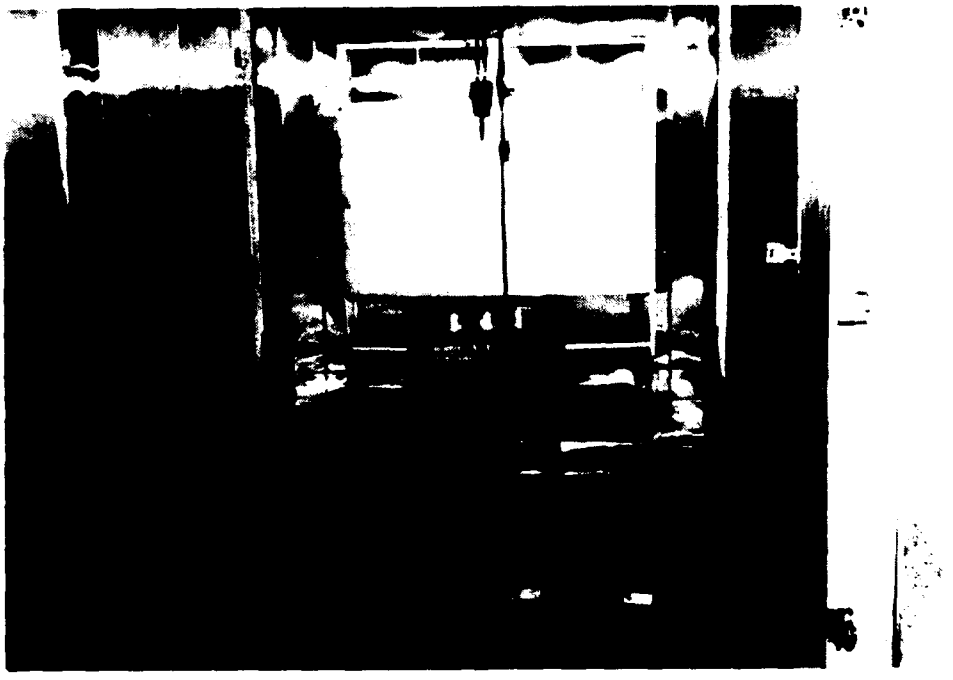

Figure 4. Low Temperature Test Chamber with Test Cups.

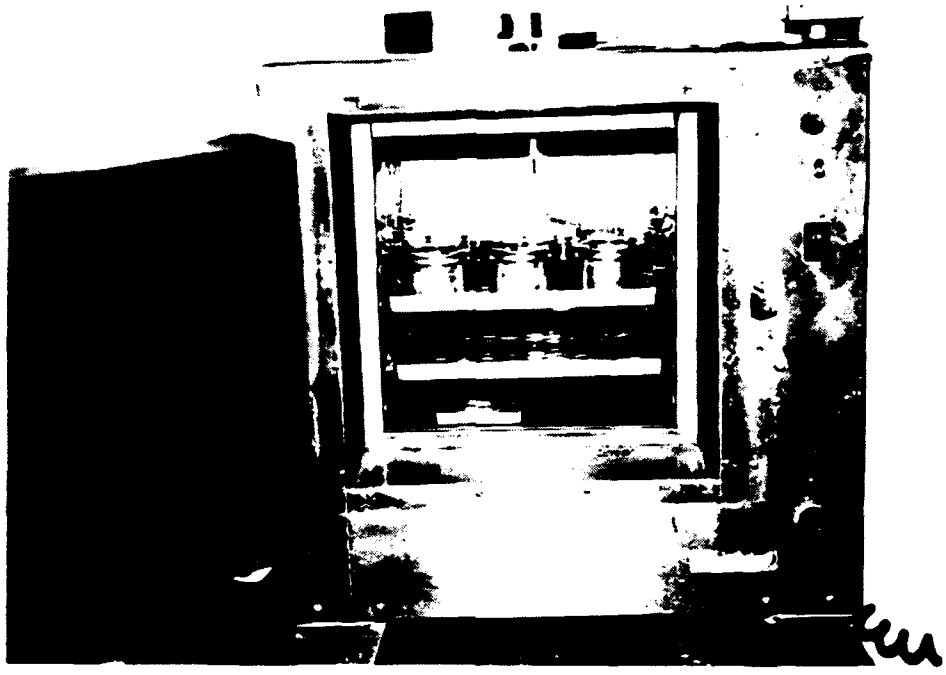

Figure 5. High Temperature Test Chamber with Test Cups.

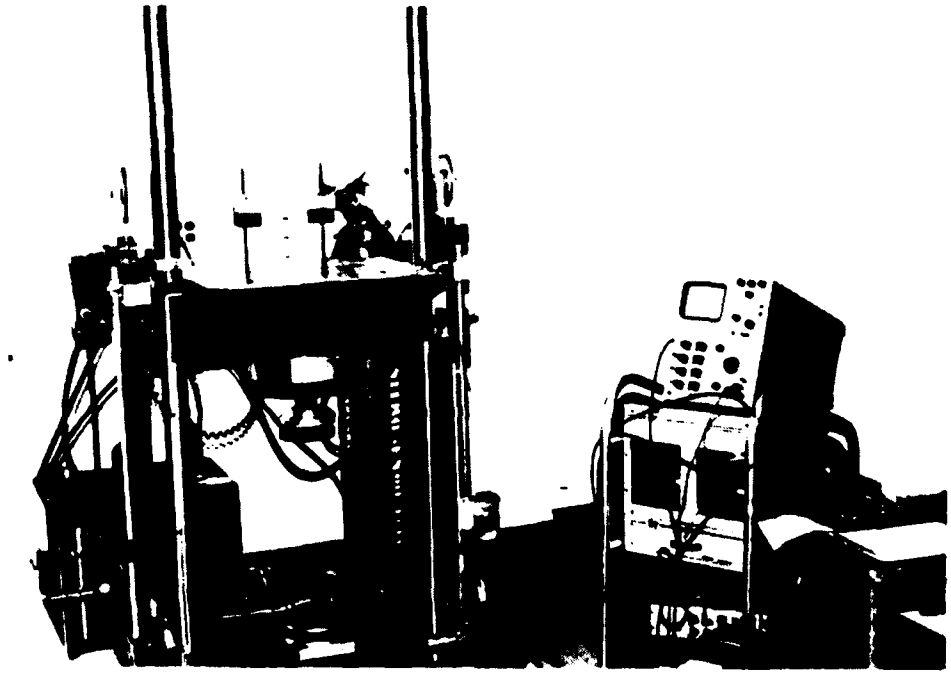

Figure 6. Shock Test Machine with JP-10 Monitors.

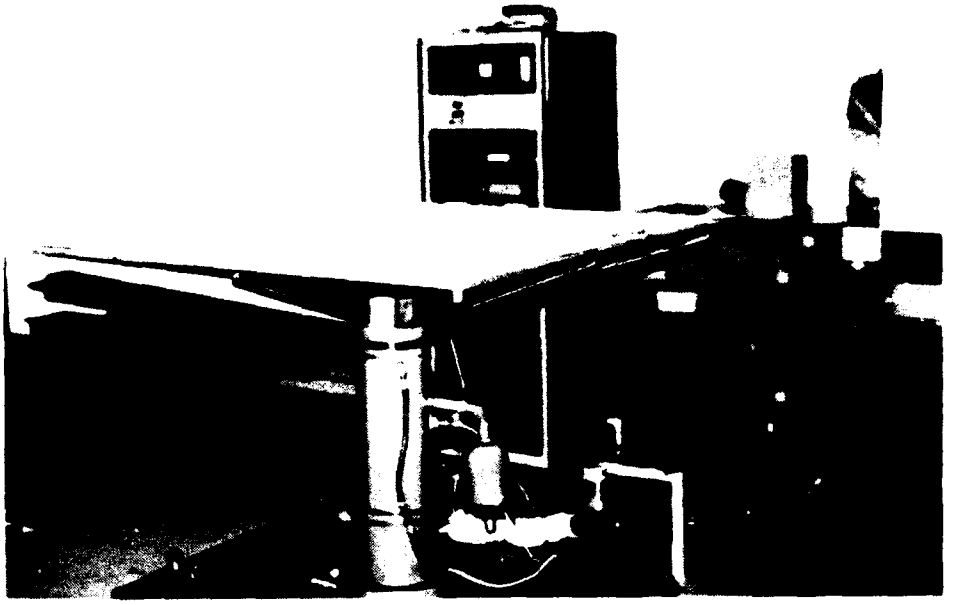

Figure 7. Vibration Test Machine with JP-10 Monitors.

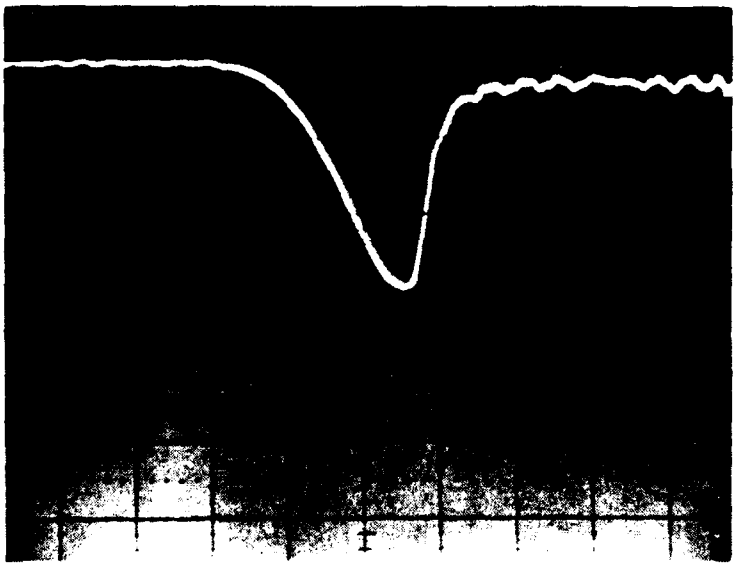

Figure 8. Shock Pulse Trace, 75 Gp, 5 msec Terminal Peak Sawtooth Pulse. (Vert Axis 25 G/div, Horiz Axis 2 msec/div)

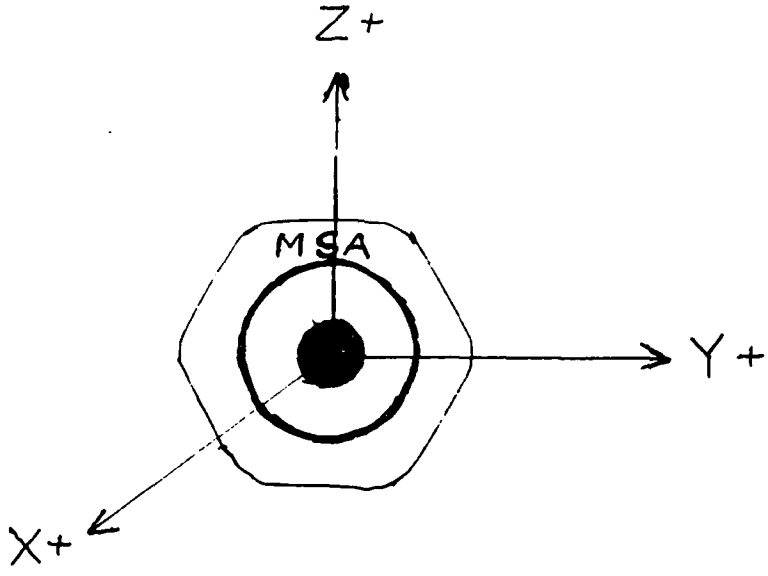

Figure 9. JP-10 Monitor, Test Axes Identification.

APPENDIX 2

TEST DATA

Mechanical Testing.

MIL-STD-810D, Method 516.3, Shock Test, Procedure V - Crash Hazard, MSA 18-72 (#7, 8, and 9) in Teflon Star Pattern Drilled Insert Mounted in Relative Humidity Indicator Housing.

Drop	Height (Inch)	Axis	Acceleration (Gp)	Pulse Duration (msec)	Damage
1	20	Z+	76	5	No
2	20	Z+	76	5	No
3	20	Z+	76	5	No
4	20	Z-	76	5	No
5	20	Z-	75	5	No
6	20	Z-	75	5	No
7	20	X+	75	5	No
8	20	X+	75	5	No
9	20	X+	75	5	No
10	20	X-	75	5	No
11	20	X-	75	5	No
12	20	X-	76	5	No
13	20	Y+	75	5	No
14	20	Y+	76	5	No
15	20	Y+	75	5	No
16	20	Y-	75	5	No
17	20	Y-	75	5	No
18	20	Y-	75	5	No

Fed-Std-101C, Method 5019.1, Vibration (Repetitive Shock) Test, MSA 18-72 (#7, 8, and 9) in Star Pattern Drilled Teflon Insert.

Test Axis	Frequency (Hz)	Acceleration (Gp)	Test Time (Min)	Damage
Z-	4.6	1.1	30	No
Z+	4.5	1.1	30	No
X-	4.5	1.1	30	No
X+	4.5	1.1	30	No
Y+	4.5	1.1	30	No
Y-	4.6	1.1	30	No